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AN ANALYSIS OF THE MAZE-LEARNING SCORES OF BRIGHT AND DULL RATS WITH REFERENCE TO MOTIVATIONAL FACTORS

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AN ANALYSIS OF THE MAZE-LEARNING SCORES OF BRIGHT AND DULL RATS WITH REFERENCE TO MOTIVATIONAL FACTORS[1, 2]

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Previous research had shown that two measures of motivation, (1) level of general activity, and (2) rate of elicitation of a conditioned response when periodically reinforced, differentiated two strains of rats which had been selectively bred, one for few errors in the maze, the other for relatively many (Harris (3)). The maze records of these animals (hereafter called brights and dulls respectively) were then examined in an attempt to discover specifically how motivational factors had operated in the maze situation to produce differences in error scores. The animals were 38 bright and 52 dull rats from the F_{12} generation of Heron's strains (5). They had been run routinely in the Heron Automatic Maze (4) before the work on motivation was begun. Examination of their time and error scores revealed two differences in behavior: (1) rate of progression or level of activity (to be defined later), and (2) number of retracing errors. Both will be shown to be functions of motivational factors.

When the average time score of each group for each trial is divided by the average number of errors in the corresponding trial, the ratios in thirteen of the fifteen trials are smaller for the bright rats (see Table I). The exceptions do not appear until the 13th and 14th trials. Two hypotheses suggest themselves as explanations of this difference in time per error ratio: (1) The time required to make an error becomes disproportionately greater as the number of errors increases. (This alternative becomes possible in view of the fact that the number of errors is greater for the dulls than for the brights.) (2) The dulls progress through the maze at a slower rate than do the brights. It is probable that both of these

[1] Taken from a Ph. D. thesis on file in the University of Minnesota Library. The author acknowledges his indebtedness to Dr. W. T. Heron who advised the research.

[2] Recommended for publication by Dr. B. F. Skinner, June 20, 1940.

TABLE I

NUMBER OF SECONDS PER ERROR OF THE F_{12} BRIGHT AND DULL RATS

(Ratios were obtained by dividing average time by average number of errors.)

Trial	1	2	3	4	5	6	7	8
Bright	20.07	16.94	14.84	12.99	14.08	13.23	13.72	14.61
Dull	28.15	35.92	24.59	19.14	19.18	27.78	21.42	20.33

Trial	9 9 9	10 10 10	11 11 11	12 12 12	13 13 13	14 14 14	15 15 15	
Bright	14.21	12.79	15.14	13.34	19.49	15.03	13.44	
Dull	19.87	16.11	16.45	15.30	15.37	12.90	13.88	

hypotheses can be shown to be correct; however, support only of the second is necessary for the argument to follow. Evidence for this hypothesis can be had by making direct comparisons of the time scores of the two groups when the number of errors is held constant. Thus, the time scores on each trial when a given number of errors were made were tabulated and averaged. It will be seen from Table II that wherever such comparisons are possible the difference in the direction of shorter time favors the brights. That

TABLE II

AVERAGE TIME REQUIRED BY THE F_{12} BRIGHT AND DULL RATS TO RUN THE MAZE MAKING A GIVEN NUMBER OF ERRORS

(Times were tabulated disregarding position of trial in the learning series)

DULL		Number of Errors	BRIGHT	
Number of Trials Tabulated	Average Time in Seconds		Average Time in Seconds	Number of Trials Tabulated
		0	42.6	8
		1	41.0	41
17	60.1	2	41.7	71
43	58.4	3	48.0	117
81	72.2	4	57.9	99
157	78.0	5	63.7	90
162	85.9	6	65.5	49
122	105.8	7	85.2	37
89	146.9	8	110.2	15
34	198.6	9		
27	221.4	10		

is, the brights require less time to complete runs where 2, 3, 4, ... errors are committed than do the dulls in similar trials. Thus, the conclusion that the dulls progress at a slower rate than the brights seems to be justified.

This difference in behavior will, of course, account for some of the difference in time scores of the two groups; but it does not account, at least not directly, for the difference in error scores. However, it can be argued that the effect of a slower rate of progression is to increase the temporal separation between the stimuli to be discriminated at the choice points, the responses made at those points, and the reinforcement by the food at the end of the

maze. There are few theories of learning that do not take into account these temporal relationships. For example, Hull's Goal Gradient Hypothesis (6) postulates a progressive weakening of the excitatory tendencies as the stimuli become more and more remote from the goal. It is interesting to note that one of the deductions that Hull made from this hypothesis was that a maze of a given length would be more difficult than a shorter one of the same pattern. This, of course, is the present finding, the effect of a slow rate of progression being to increase the (temporal) length of the maze.

Rate of progression as here used does not necessarily imply speed of ambulatory movements. Another possibility is that the dulls are completely inactive for a greater percentage of the elapsed time. Perhaps level of activity would be a more descriptive term. Specifically what the rat is doing is not important for the above argument. The significant thing is the temporal delay introduced.

In the foregoing discussion, rate of progression or level of activity has been assumed to be a function of motivational factors. As justification, appeal is made to common usage. Level of gross bodily activity as measured either by revolving drums or by tambour-mounted cages has been shown to vary systematically with various operations performed on the animal, e.g., fasting, temperature variation, endocrine-gland removal, etc, (8). These are the kind of operations which are usually accepted as defining drive.

The second difference in behavior between the strains is in number of retracing errors. In a maze-learning situation where retracing errors are prevented, a group of animals on the first trial should show exactly half as many errors as there are blind alleys. This is based on the assumption that the animals have no consistent tendencies toward making a right turn rather than a left at each choice point, and that the choice is made on the basis of chance factors. The Heron maze presents twelve choice points and prevents retracing to a previously passed choice point, but does not prevent perseverative errors (running back and forth in a blind and closing the error-recording switch more than once). In such a maze one would expect the average number of errors of a group of rats to be somewhat more than six in the early trials, and that the number

would drop below that figure with further exposure of the animals to the maze. This is what happens in the bright group; however, the error scores of the dull rats remain consistently above the "chance" level for the first eleven trials (see the solid line performance curves of Figure 1). That the discrepancy between the expected average and the average actually obtained is due to the persistence of a greater number of retracing errors in the dull rats can be shown by plotting only the average number of forward-going errors for the two strains. (See dotted curves of Figure 1.)

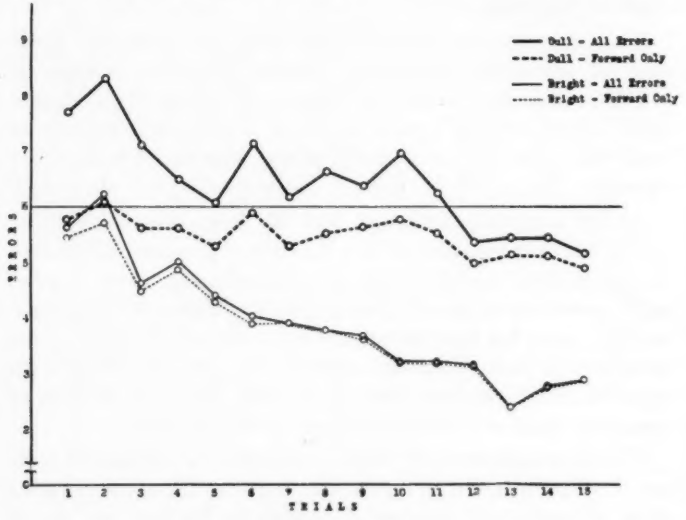

FIGURE 1
Maze-Performance Curves of F_{12} Bright and Dull Rats.

The total error curves, which appear to be quite parallel, showing about equal rates of acceleration, and thereby indicating an equally rapid rate of elimination of errors in the two groups, obscure, then, an important difference between the strains. In the bright rats, the drop in total error curve represents the elimination of forward-going errors, a progressively greater percentage of correct turns at the successive choice points. In the dull rats, the

drop represents almost entirely the elimination of retracing errors; the curve of forward-going errors remains horizontal for the first eleven trials, only slightly below the "chance" line at six errors. Such a curve could be explained by two hypotheses: (1) The maze is too difficult for the dull rats. (2) Goal-directed behavior, i.e., a preference for the shortest path to the food, does not appear because of weak drive. Crucial experimental evidence for choosing between these hypotheses is not available in the present data. However, certain indirect evidence from other work can be adduced to show that the motivation hypothesis is tenable even though the possibility that the first hypothesis is correct cannot be ruled out. For example, the behavior of the dull rats is similar to that of non-hungry rats in a maze (1), (7), or to that of hungry rats after the food has been withdrawn from a previously learned maze (2), (7). The usual inference made from such behavior is that the food at the end of the maze and the physiological condition of the animal with reference to it have a directing effect on the performance of the rat; in short, that error score in the maze is in part, at least, a function of motivational factors.

The explanation offered here, then, for the almost exactly "chance" level of forward-going errors in the dull rats for a considerable portion of the learning period is that because of the relatively weaker drive in these rats the goal does not exercise its directing effect to as great an extent as in the brights. The relatively large number of retracing errors in the dulls is seen as the operation of other drives, e.g., exploratory drive, at greater strength than the hunger drive.

It should be pointed out that this explanation of retracing errors is not unequivocally demonstrated by the present data. It is logically as defensible to postulate some other non-motivational factor to account for the facts, e.g., a "perseverative tendency," which would explain retracing errors as a tendency to repeat an activity just performed, in this case to return to the end of a blind alley after once leaving it. Such hypotheses could, of course, be multiplied without end. A critical test of the motivation hypothesis would be to increase motivation by decreasing daily food intake and thereafter to observe the number of retracing errors. Even

in the absence of such experimental data, the writer prefers the motivation hypothesis because it economically explains not only retracing errors, but forward-going errors persisting at chance level as well; and evidence not completely available indicates that the two phenomena are interrelated.

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